The effects of rainfall partitioning and evapotranspiration on the temporal and spatial variation of soil water content in a Mediterranean agroforestry system

[1]Biel, C., [1]Molina, A.J., [1]Aranda, X., [2]Llorens, P. and [1]Savé, R.

[1]IRTA - Torre Marimon, 08140 Caldes de Montbui, Spain. [2]IDAEA-CSIC, Department of Geoscience, Barcelona, Spain

*Corresponding author: e-mail: carmen.biel@irta.cat Telephone: +34 934 674 040, Fax: +34 938 650 954

Introduction and objectives

Tree plantation for wood production has been proposed to mitigate CO_2-related climate change. Although these agroforestry systems can contribute to maintain the agriculture in some areas placed between crops and secondary forests, water scarcity in Mediterranean climate could restrict its growth, and their presence will affect the water balance. Tree plantations management (species, plant density, irrigation, etc), hence, can be used to affect the water balance, resulting in water availability improvement and buffering of the water cycle.

The present work studies how the temporal and spatial variation of soil water content is affected by transpiration and interception loss fluxes in a Mediterranean rainfed plantation of cherry tree (*Prunus avium*).

Materials and methods

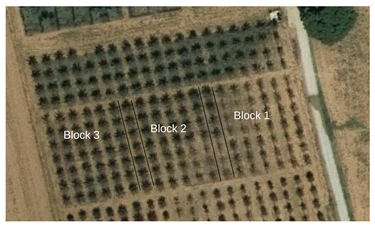
A five-years-old cherry tree plantation located in northeast of Spain at 4x4 m spacing was studied without any soil tillage. Tree height and trunk diameter were 4.46 m±0.28 and 5.42 ±0.29 cm at the beginning of the year.

From April till December 2011 were continuously monitored:

- Meteorological variables: rainfall, air temperature, solar radiation, wind speed and relative humidity.
- Throughfall and stemflow in 6 trees, with 7 automatic tipping-bucket per tree.
- Transpiration in 3 trees by means of heat pulse sap flow sensors (HRM30, ICT Int. Australia). Daily sap flow (L day^{-1}tree^{-1}) was converted to daily tree transpiration (mm day^{-1}) according to the tree density of 625 tree ha^{-1}.
- Soil water content (SWC) at 25 and 50 cm depths under selected trees (at a distance of 60 cm from the trunk) and between tree rows exposed to direct sun with capacitive sensors (10HS, Decagon Devices, USA).
- Tree relative green coverage through zenith digital pictures.

Soil water content variation (SWCv) was compared under tree and between tree rows at different time scales in order to know the effect of:

- Tree transpiration: as the accumulated depletion in the first 50 cm soil depth in successive days without rain.
- Rainfall interception: as the soil water content recharge at the first 25 cm soil depth as the difference between the SWC before and after rainfall events from 1 to 30 mm.



Picture 1. Photography of the plot with block distribution (August 16 2011 (institut cartogràfic de Catalunya).

Picture 2. Tree with sap flow sensor, and tree with raingauges.

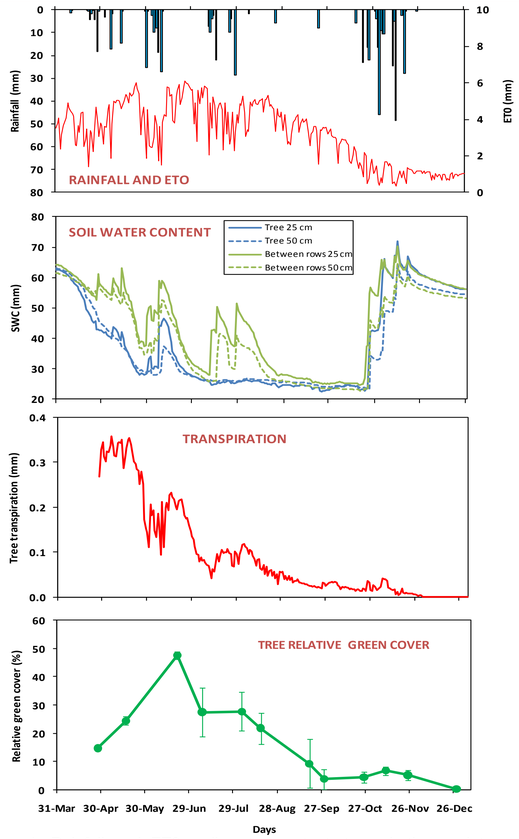


Figure 1. Rainfall and ET0, soil water content, transpiration and tree relative green cover during the growing season. Values of soil water content , transpiration and tree relative green coverage are the average of 3 trees.

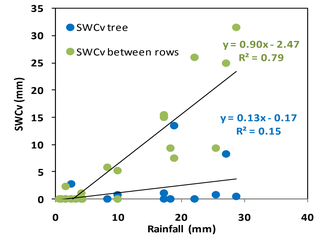


Figure 2. Relationship between rainfall and soil water content variation (SWCv) under tree cover and between rows. Values are the average of 3 points for rain event.

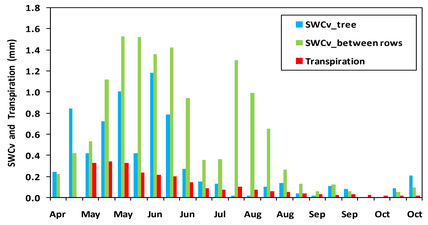


Figure 3. Soil water content variation (SWCv) under tree cover and between rows, tree transpiration and ET0 in rain-free days. Values are the average of 7 days.

Results and discussion

Annual rainfall and ET0 during 2011 were 771 and 1088 mm respectively. During the growing season (from March 30th till November 1st) rainfall and ET0 were 537 and 942 mm (Fig. 1), and climatic deficit (ET0-Rainfall) was 405 mm. Until the end of June, tree transpiration was maintained to the highest rate, due to SWC availability and optimal climatic conditions. However, a drastic reduction of tree transpiration occurred during summer, paralleled to a decrease of the SWC under tree and the tree coverage (Fig.1).

SWC dynamics “under tree” and “between tree rows” were similar till April 2011, despite the water consumption estimated as SWCv was higher in “under tree”. From that moment, SWCv was always higher in “between rows” in days with and without rainfall (Fig. 2 and 3). In rainy days, this SWCv difference can not be explained by throughfall alone (mean of 83 % of rainfall, Fig.4), due to the clear disagreement with the SWCv estimated “under tree”. On the other hand, in rain-free days, tree transpiration explained 64 % of the SWCv (Fig.5). Similarly, the higher evapotranspiration in the “between rows” should reflect a higher transpiration in this area, including effect of the herbaceous cover and the tree.

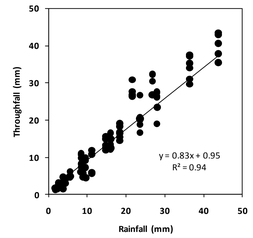


Figure 4. Relationship between rainfall and throughfall.

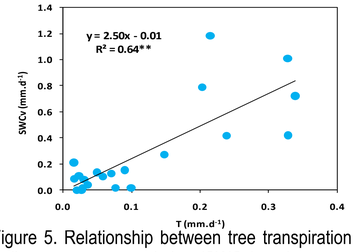


Figure 5. Relationship between tree transpiration and Soil water content variation (SWCv) under tree cover in dry periods. Values are the average of 7 days.

Conclusion

Our preliminary results show that there is a different SWC pattern depending on the measurement point. In this sense, apart from the hydrological processes of transpiration and interception that are believed to be the main driving forces, other factors not controlled in the experimental design (e.g. crust formation, soil water content redistribution, soil heterogeneity), affected the results.

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